Temporal variations in abundance and species composition of fish and epibenthic crustaceans of an intertidal zone: Environmental factor influence

by

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ABSTRACT. - Fishes and epibenthic crustaceans were sampled for 1 year with a 1.5 m beam trawl in the intertidal zone of a sandy beach of the Eastern Channel. The intensity by which this intertidal zone is used by fishes and crustaceans was analyzed as well as the environmental factors influencing temporal variations in diversity, species abundance and assemblages. Between February 2005 and January 2006, 16 species were recorded. The presence of many juvenile indicated the important role played by the intertidal zone as a nursery ground. The brown shrimp *Crangon crangon* and O-group plaice *Pleuronectes platessa* are the two most abundant species of the intertidal ecosystem. Although the studied intertidal area is a multispecific nursery area, only six species had a major influence on the variation in total densities and can be considered as key species. Clear seasonal succession was observed in the species composition. The main structuring variables determining the occurrence and abundance of most of the species are water temperature, turbidity and dissolved oxygen. For some species, peak densities were observed during spring tides, suggesting selective tidal transport. Extreme winter conditions and subsequent migration of organisms to deeper water caused a decline in winter in both density and diversity.

RÉSUMÉ. - Variations temporelles de l'abondance et de la composition spécifique des poissons et crustacés épibenthiques d'une zone intertidale : influence des facteurs environnementaux.

Des échantillonnages de poissons et de crustacés épibenthiques ont été effectués à l'aide d'un chalut à perche de 1,5 m au niveau d'une zone intertidale en Manche orientale. L'occupation de cette zone par les espèces a été analysée ainsi que les facteurs environnementaux influençant les variations temporelles de la diversité, des abondances et des assemblages. Entre février 2005 et janvier 2006, seize espèces ont été capturées. La présence de nombreux juvéniles indique le rôle de nourricerie joué par la zone. La crevette grise *Crangon crangon* et la plie *Pleuronectes platessa* sont les deux principales espèces rencontrées. Bien que la zone étudiée soit multispécifique, seules six espèces ont une influence majeure sur les variations totales des densités et peuvent être considérées comme espèces clés. La composition observée des espèces montre une nette succession saisonnière. Les principales variables environnementales déterminant l'occurrence et l'abondance de la plupart des espèces sont la température, la turbidité et l'oxygène dissous. Pour quelques espèces, les pics de densités ont lieu durant les marées de vives eaux, suggérant un transport sélectif de leurs larves par la marée. Les rudes conditions et la migration des individus vers les eaux plus profondes en hiver expliquent les chutes de densité et de diversité.

Key words. - Fish - Crustaceans - ANE - Eastern Channel - Composition - Intertidal zone - Temporal variations - Environmental factors.

Use of shallow marine coastal zones and estuaries as nursery areas is an important phase of the life history of many marine organisms, including many commercially valuable species. The species composition in these areas varies temporally and spatially, based mainly on migrations of seasonal visitors and is often the result of seasonal settling or consecutive migration waves of young stages. Indeed, most of these species spawn in deeper offshore waters and invade, as late larvae or early juveniles, shallow coastal areas in spring and summer, when such areas are relatively warm and rich in food (Bergman *et al.*, 1988; Marchand, 1991; Amara, 2003).

Relatively few species are adapted to thrive in conditions such as fluctuating temperature, salinity or turbidity (Gibson *et al.*, 1993). If some species remain in the subtidal zone, the young stages of various marine species have developed the ability to use the intertidal zone during high tide (Gibson, 1973; Van der Veer and Bergman, 1987; Beyst, Buysse *et al.*, 2001). 'Intertidal species', as opposed to 'subtidal' or 'shore species', are defined as species, which utilized the intertidal zone for completion of all or an essential part of their life history (Gibson, 1982). This is not necessarily dependence on intertidal environment, merely opportunistic utilisation of a near-shore environment offering refuge from predators and increased feeding possibilities (Blaber and Blaber, 1980). The factors governing habitat choice are poorly known, but intertidal zones are generally considered as favourable habitats for juvenile feeding and growth (Gibson, 1982, Van der Veer and Witte, 1993). Although the shallow water fauna have been studied intensively, only few studies of intertidal

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sandy beaches have considered both fish and epibenthic crustacean assemblages (Gibson *et al.*, 1993; Beyst, Hostens *et al.*, 2001; Amara and Paul, 2003). In spite that intertidal zone are highly fluctuating environment, the influence of environmental factors on community structure and population dynamic of intertidal zone is poorly known (Beyst, Hostens *et al.*, 2001).

The aims of the present study were (1) to describe the seasonal pattern in the community of fishes and epibenthic crustaceans of an intertidal zone of a sandy beach and to assess the role and importance of this zone as a nursery area for marine species, and (2) to analyze environmental factors influencing or controlling temporal variations in diversity, species abundances and assemblages.

MATERIALS AND METHODS

Study area and sampling

The study was carried out on the intertidal zone of a sandy beach located near a small estuary (La Canche) on the French coast of the Eastern Channel (Fig. 1). The distance between high and low watermark was about 700 m at neap tide and 1500 m at spring tide. The average tidal range was about 7 m on spring tide and 3 m on neap tide. Two stations, considered as duplicates because of their nearness, were sampled during daytime in the intertidal zone (Fig. 1) from February 2005 until January 2006. Weekly sampling was performed between mid February and early June and every month other time (either 23 sampling dates). Sampling was done with a 1.5 m beam trawl during the day. The fishing net was 5.5 m long, had a mesh size of 8 x 8 mm in the main body and 5 x 5 mm in the codend and was equipped with a tickler-chain in the ground rope. The gear was pulled by two persons at constant speed in average depth of water of 0.8 m (0.2 to 1.2 m) corresponding to high tide + 3 h. The distance covered by the gear was about 250 m representing a sampling surface of about 400 m².

Temperature, salinity, pH and dissolved oxygen were recorded at the start of each trawl using a TetraCon 325 multiprobe. Turbidity was also measured using a Cyberscan probe. Environmental results are presented as an average of the values measured at each station afterward. Tide coefficients and lunar cycle, which are also an important factor structuring the abundance of individuals (Letourneur, 1996; Raventos and Macpherson, 2005), were also taken into account in the analyses.

Data analysis

All fishes and epibenthic crustaceans were identified to species level (except for Clupeidae which were not identified due to the difficulty for the identification of larval and juvenile stages) and counted. For each species, catch numbers were converted to density estimates (expressed as number of individuals per 1000 m²). Afterward, density of each species for each date is represented as a mean of the two stations.

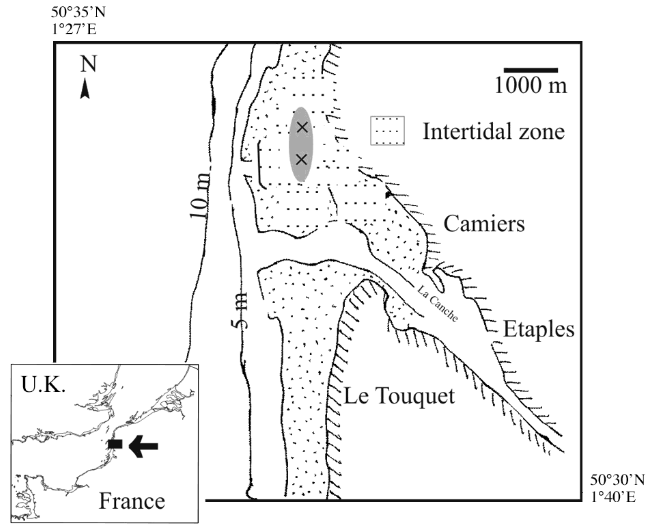


Figure 1. - Study area with location of the two stations (x) in the intertidal zone. *[Zone d'étude et localisation des deux stations (x) au niveau de la zone intertidale.]*

The fish and epibenthic crustaceans community were characterized using either the species richness S (total number of species obtained at each sampling), or the Shannon-Wiener diversity index H' (Shannon and Weaver, 1963): $H' = -\sum_{i=1}^{S} Pi.\ln Pi$, where Pi is the proportion of individuals in the i-th species.

Distribution of individuals was measured by the uniformity or 'evenness' index, J (Pielou, 1966): J = H' / ln S. When individuals are distributed homogeneously between species, J tends to 1. Inversely, values close to 0 indicate disequilibrium of the structure and the dominance of few species.

Statistical analyses

One-way analyses of variance (ANOVA) were used (SYSTAT 10) to test for temporal variations of fish and epibenthic crustaceans' abundances, variations of population index and variations of environmental variables. In the event of significance, an a posteriori Tukey test was used to determine which means were significantly different at a 0.05 level of probability. For the study of seasonal variations of the environmental factors, seasons were aggregated into "three-months groups": Winter comprised January, February and March; spring: April, May and June; summer: July, August, September, and autumn: October, November and December.

Canonical correspondence analysis (CCA) using CANOCO package (Ter Braak, 1986) was used to examine the associations between species and environmental variables. CCA is a method that relates population data to environmen-

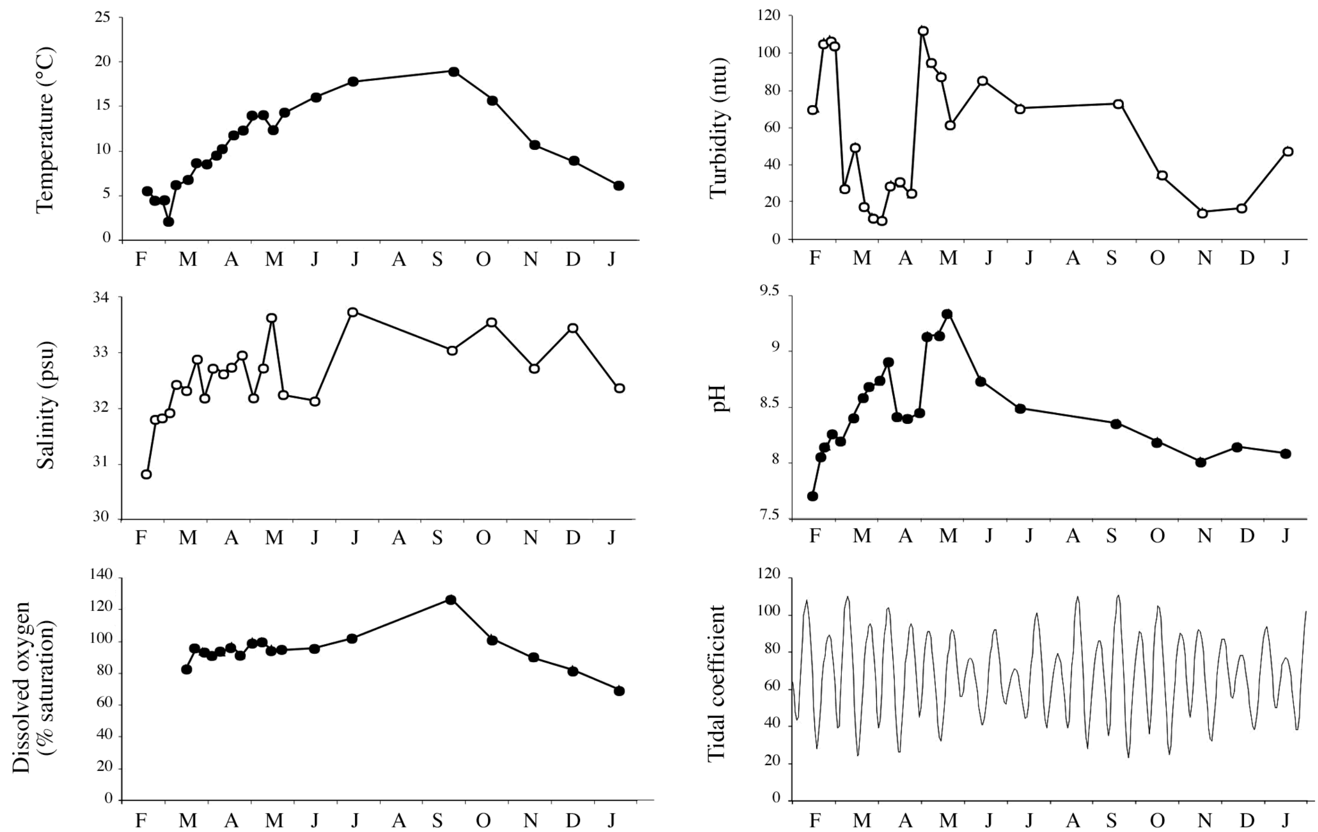


Figure 2. - Temporal variations of the environmental variables (average of the two stations) measured between February 2005 and January 2006 in the intertidal zone. *[Variations temporelles des variables environnementales (moyenne des deux stations) mesurées entre février 2005 et janvier 2006 en zone intertidale.]*

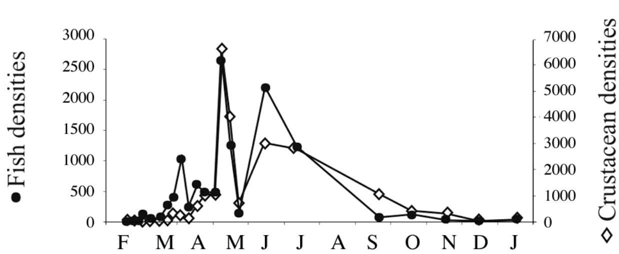


Figure 3. - Temporal variations of fish and epibenthic crustacean mean densities (nb.1000 m^{-2}) during sampling period (February 2005 to January 2006). *[Variations temporelles des densités moyennes de poissons et crustacés épibenthiques (nb.1000 m^{-2}) au cours de la période d'échantillonnage (février 2005 à janvier 2006).]*

tal factors by constraining species ordination to a pattern that correlates with environmental variables (Ter Braak, 1986). To test the significance of each variable's contribution to each axis, Monte Carlo permutation analysis was used. Temporal patterns of the abundance of each species in the intertidal zone were also examined to obtain a grouping of the sampling dates, based on species composition.

RESULTS

Environmental conditions

Seasonal trends in abiotic factors are shown in figure 2. As in other temperate areas, temperature showed a classical seasonal pattern. Temperature increases gradually from 5°C in February to a maximum of 18.7°C in late September, declining subsequently in October and reaches low values in winter. Summer temperatures are highest than other seasons (ANOVA, $p < 0.001$). Salinity varies from 30.67 (18/02) to 33.6 (13/07) around an average salinity of 32.43 (± 0.68). Summer and autumn salinity values are higher than winter and spring values ($p < 0.01$). Values of pH increase until May (9.35) declining progressively until winter (8.02, 18/11). Water turbidity is low during March-April and during autumn and early winter. Highest values are recorded in February and May (± 110 NTU). Dissolved oxygen is relatively constant during the study, at about 94.8% of saturation ± 11.3.

Fish and epibenthic crustacean community

Fish and epibenthic crustaceans are present all year

Table I. - Species composition, mean densities (nb.1000 m^{-2}), percentage of abundance and occurrence (sample percentages in which they were present) of fish and epibenthic crustaceans captured between February 2005 and January 2006. *[Composition des espèces, densités moyennes (nb.1000 m^{-2}), pourcentage d'abondance et occurrence des poissons et crustacés épibenthiques capturés entre février 2005 et janvier 2006.]*

	Family	Species (abbreviations)	Mean densities	% Abundance	% Occurrence
Fishes	Pleuronectidae	*Pleuronectes platessa (P pla)*	185.91	13.40	69.57
	Scophthalmidae	*Psetta maxima (P max)*	0.36	0.03	8.7
	"	*Scophthalmus rhombus (S rho)*	0.07	0.01	4.3
	Clupeidae	*(Clup)*	168.42	11.90	60.87
	Moronidae	*Dicentrarchus labrax (D lab)*	1.92	0.14	26.09
	Ammodytidae	*Ammodytes tobianus (A tob)*	30.64	2.13	56.52
	Gobiidae	*Pomatoschistus microps (P mic)*	99.94	7.06	82.61
	Atherinidae	*Atherina presbyter (A pre)*	0.25	0.02	8.70
	Syngnathidae	*Syngnathus acus (S acu)*	0.29	0.02	13.04
Crustaceans	Crangonidae	*Crangon crangon (C cra)*	833.79	58.92	95.65
	Portunidae	*Carcinus maenas (C mae)*	64.01	4.52	60.87
	"	*Portumnus latipes (P lat)*	1.45	0.10	13.04
	Palaemonidae	*Palaemon longirostris (P lon)*	0.07	0.01	4.35
	Gammaridae	*Gammarus* sp. *(Gamm)*	4.94	0.35	26.09
	Mysidacae	*Gastrosaccus spinifer (G spi)*	22.82	1.60	60.87
	Idotheidae	*Idothea* sp. *(Idot)*	0.65	0.05	4.35
Total	14	16	1415.53	100.00	100.00

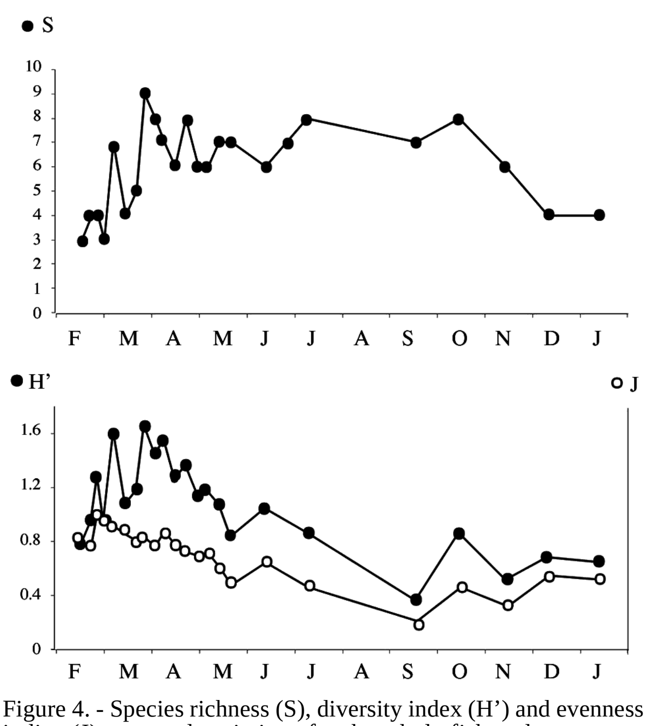


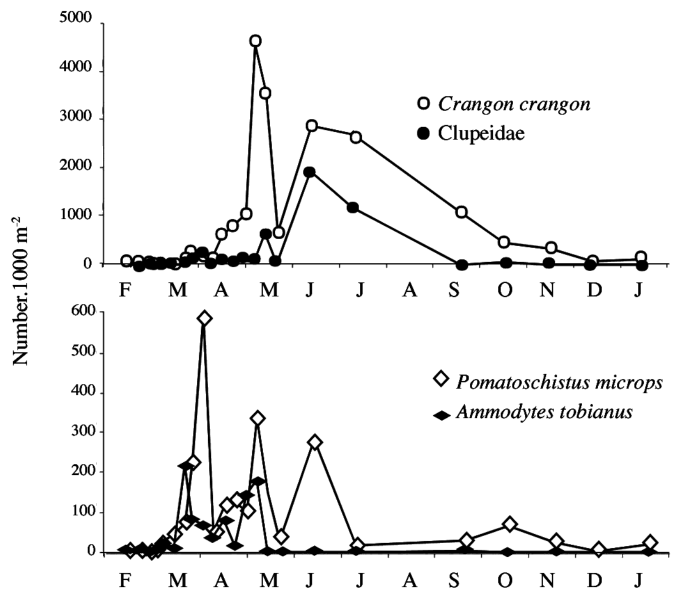
Figure 4. - Species richness (S), diversity index (H') and evenness indice (J) temporal variations for the whole fish and crustacean assemblage. *[Variations temporelles de la richesse spécifique (S), de l'indice de diversité (H') et de l'indice de régularité (J) de l'ensemble des poissons et des crustacés.]*

round in the intertidal zone. A total of 16 species (9 fish species and 7 epibenthic crustaceans) belonging to 14 families were caught during the investigations (Tab. I). Most of them are larvae or juveniles often from species of commercial importance. The highest fish density (all species together; 2,653 fish.1000 m^{-2}) occurs in early-April with a second peak in mid-June (Fig. 3). The period between September and March was characterized by low abundance and biomass. Epibenthic crustacean density evolution shows the same trend as fish density. The highest value recorded is 5,613 ind.1000 m^{-2}.

Diversity index shows seasonal trend (Fig. 4). Species richness is low in winter and relatively constant the rest of the year. Shannon diversity (H') and evenness (J) index decrease from March to September.

Only 6 species were defined as dominants (occurrence > 50% and abundance > 2% of the total catches) and can be considered as key species. Among these species, the two principal are the brown shrimp *Crangon crangon* (Linnaeus, 1758) and the plaice *Pleuronectes platessa* (Linnaeus, 1758) at juvenile state because they are the most abundant in the intertidal zone. In addition to these two principal species, four species can be also considered as key species of the intertidal sandy beach since they are the most frequently sampled. These species are the goby *Pomatoschistus microps* (Krøyer, 1838), the Clupeidae, the shore crab *Carcinus maenas* (Linnaeus, 1758) and the small sandeel *Ammodytes tobianus* (Linnaeus, 1758).

Fluctuations in densities of the key species over the study period are shown in figure 5. Young plaice (metamorphosing and newly settled individuals) are present from late March, reaching a peak density of about 2,120 ind.1000 m^{-2} in early-May followed by a rapid decline in the following week to a density of less than 120 ind.1000 m^{-2}. The Clupeidae are caught mainly during summer while sand gobies are



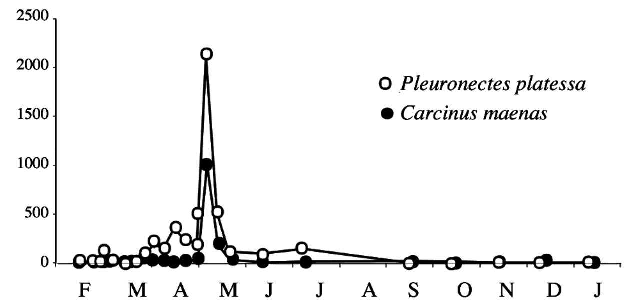


Figure 5. - Temporal variation of dominant species mean densities of fishes and crustaceans in the studied zone. *[Variations temporelles des densités moyennes des espèces dominantes de poissons et de crustacés de la zone étudiée.]*

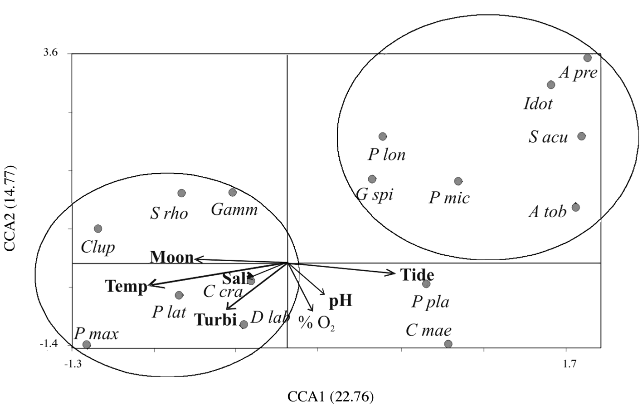


Figure 6. - CCA ordination diagram including fish and epibenthic crustacean species with environmental parameters represented by vectors. See table I for abbreviations. *[Analyse canonique des correspondances incluant les espèces (poissons et crustacés épibenthiques) et les paramètres environnementaux, représentés par des vecteurs. Voir le tableau I pour les abréviations.]*

present throughout the sampling period with a peak density of about 600 ind.1000 m^{-2} in late March. Small sandeel *Ammodytes tobianus* are essentially found during spring. The brown shrimp is by far the most abundant (mean density during the period of study: 833 ind.1000 m^{-2}) and contribute to 59% of the total catch. This species is present all year-round (96% frequency of occurrence), but more abundant from mid-May to early August (Fig. 5). Shore crabs are also regularly caught (61% frequency of occurrence) but they are less abundant than *Crangon crangon*. This species shows a peak of density in early-May. The other species could be considered as occasional or rare and contribute for only 2% of the total catch. For most species, peak densities occur during spring tides.

Influence of environmental factors

The canonical correspondence analysis reveals that the significant ($p < 0.05$) environmental parameters associated with species abundance are temperature, turbidity and dissolved oxygen. CCA eigenvalues of the first four axis are 22.8% (CCA 1), 14.8% (CCA 2), 5.9% (CCA 3) and 3.3% (CCA 4). Correlations between species and the four environmental axes are high for the first three axes (0.97, 0.86 and 0.89 respectively). Cumulative percentage variance of species for the four axes is 49.6. The first and second axes model 24.2 and 39.8% of species data respectively, and account for 75.3% of species-environment relation modelled by the CCA. Therefore, results obtained from the first two axes are plotted (Fig. 6) although 4 axes were determined within the analysis.

The importance of a variable on the CCA plots is indicated by the length of vector of this given variable. Temperature, which had the longest vector along the first axis, is significantly correlated (-0.75) with the first axis, which explains most of the variation in the species data. The second axis is significantly associated with dissolved oxygen (-0.81) and turbidity (-0.77). These three factors (temperature, turbidity and dissolved oxygen in order of importance) are able to predict 37% of the temporal variability of the total catches within the intertidal zone studied. In addition, tide is another important factor influencing some species, such as plaice for which density peak occurs during spring tides. All variables were included in the graph to demonstrate their relative positions. Species plotted closer to the vector have stronger relationships with them. Species located near the origin do not show a strong relationship to any of the variables and are found at average values in relation to environmental factors. Thus, many species, such as *Atherina presbyter* (Cuvier,

1826), *Ammodytes tobianus*, *Syngnahus acus* (Linnaeus, 1758), *Psetta maxima* (Linnaeus, 1758), Clupeidae, indicate a high response to the temporal temperature variations. The two temperature or temporal groups (Fig. 6) could be described as either low-temperature or high-temperature preference/tolerance taxa. In contrast, few species in the study area have average values in relation to environmental variables. The major source of variation in the data is a marked change in fish and epibenthic crustacean structure between autumn-winter and spring-summer.

DISCUSSION

The fish and epibenthic crustacean community

The majority of fish and epibenthic crustaceans captured were juveniles: this underlines the important role played by the intertidal zone as a nursery ground. Seasonal fluctuations in species richness and composition seem to be typical of many fish communities in coastal shallow marine waters (Gibson *et al.*, 1993; Amara, 2003; Greenwood and Hill, 2003) with highest values during spring period (March to May). In the present study, seasonal patterns were evident in either the density or species diversity of the fish and epibenthic community. This seasonality in density and in the composition of the fish and epibenthic community of the intertidal zone largely reflects the different times of recruitment of different species, as observed in other areas (Gibson, 1973; Beyst, Hostens *et al.*, 2001), themselves explained by spawning period of the species. For example, observed recruitment period of three months (March to early-June) for plaice is due to spawning season of this flatfish species from January to March in the North Sea (Bromley, 2000). Most species spawn in deeper offshore waters, which may be favourable for egg survival and dispersion (Blaber *et al.*, 1997). After hatching, larvae are drifted to the coast and then migrate to shallow intertidal areas using the tides as a means of transport (Daan *et al.*, 1990; Cattrijsse *et al.*, 1997). For temperate waters, this pattern of movements results in consecutive migration waves of juveniles of marine fish, crabs and shrimps (Zijlstra, 1972; Gibson *et al.*, 1993; Santos and Nash, 1995).

The observed species composition and diversity in the intertidal zone studied were comparable to other northern Europeans intertidal zones (Gibson, 1973; Santos and Nash, 1995; Beyst, Hostens *et al.*, 2001). Between February 2005 and January 2006, 16 species (9 fishes and 7 crustaceans) belonging to 14 families were caught, more than half of which occurred only rarely. The brown shrimp and juvenile plaice are the two most abundant species of the intertidal ecosystem. As in most shallow water communities, a few species are dominant (Ross *et al.*, 1987). For example, Beyst, Hostens *et al.* (2001) found 7 dominants species in Belgian sandy beaches. These species are the same of these observed in the present study, namely *Crangon crangon*, *Carcinus maenas*, *Pleuronectes platessa*, two Clupeids species and two gobies. Indeed, relatively few species are adapted to thrive in conditions such as fluctuating temperature, salinity or turbidity.

The advantages for marine species using the intertidal zone during part of their life cycle are not well known. This is not necessarily dependence on the intertidal environment, merely opportunistic utilisation of a near-shore environment offering refuge from predators and increased feeding possibilities (Bergman *et al.*, 1988; Van der Veer and Witte, 1993; Cattrijsse *et al.*, 1997; Amara and Paul, 2003). For example, it is generally agreed that the movement of juvenile fish and crustaceans into the intertidal zone is concerned with feeding, using the considerable resources of the intertidal area, which are only available to them when immersed. This view of the intertidal zone as a habitat beneficial for rapid juvenile growth has been confirmed for plaice (Van der Veer and Witte, 1993).

The abundance of intertidal fish species is generally highest in spring and summer due to the influx of juveniles of marine species following their breeding seasons (Gibson and Yoshiyama, 1999; Amara and Paul, 2003). In this study, spring collections were dominated by plaice, which comprises 52% of the total fishes catch during this period. Sand gobies are among the most abundant fish of shallow coastal areas, estuaries and marine bays of the European coast (Fonds, 1973; Hamerlynck and Cattrijsse, 1994). In the intertidal zone studied, owing to their repeated and long spawning period (Amara and Paul, 2003), gobies were present throughout the study with density peaks in spring and summer explained by migration waves of the juveniles descended from different spawning periods. Clupeids species (larvae and juveniles) are also an important component of the intertidal fish community but only during a short period (June-July). Epibenthic crustacean density evolution showed the same trend as fish density. As in other shallow waters in northern Europe, the brown shrimp is the dominant mobile epibenthic species (e.g. Kuipers and Dapper, 1984; Beyst, Hostens *et al.*, 2001). This crustacean species and the shore crab *Carcinus maenas* are both ubiquitous members of the large motile epifauna of shallow water communities (Gibson *et al.*, 1993).

Temporal variations and influencing factors

According to the CCA diagram ordination, the main abiotic factors explaining the temporal fish and crustacean abundance are temperature, turbidity and dissolved oxygen. It is generally the case that only few environmental variables explain the species composition and abundance in shallow waters (Raventos and Macpherson, 2005). Abiotic water conditions (salinity and temperature) are often evoked as

controls for seasonal patterns of species occurrence (Whitfield *et al.*, 1981; Thiel *et al.*, 1995; Lazzari *et al.*, 2003). Most species utilize the shallow intertidal areas during the spring and summer and then migrate to deeper waters during cooler months, leaving the remaining winter assemblage low in diversity and number and represented by only the most physiologically tolerant species (Gibson *et al.*, 1993; Santos and Nash, 1995; Lazzari *et al.*, 2003). This seasonal migration is supported by the significant relationship between species abundance and temperature. Although not directly demonstrated here, it seems likely that temperature either directly or indirectly (e.g. by influencing the timing of spawning), is the underlying mechanism of seasonal shallow intertidal dynamics. Temperature can affect fish and crustacean distributions through the thermal tolerances of species. This variable explains the division in two groups of species (Fig. 5). The first group constituted by species occurring during high temperature ('spring and summer species') whereas the second occurred when the intertidal zone temperature is low ('winter species'). In Belgian sandy beaches, Beyst, Hostens *et al.* (2001) found a similar assemblage with species composition variations between seasons according to direct or indirect species tolerance to the temperature.

Another important factor affecting the assemblage is turbidity. The importance of this environmental variable in shallow water areas is attributed to the fact than turbidity reduces interspecific and intraspecific predation risks through the reduction of light intensity in the nursery ground (Blaber and Blaber, 1980). In addition, turbid areas often supply large food resources attractive to juveniles. Although exposed as significant by the CCA, dissolved oxygen does not seem to be an important factor structuring the assemblage in the present study; low values able to affect species were never measured throughout the study period.

The present results showed that for many fish and crustacean species (e.g. plaice, brown shrimp, shore crab), the highest densities were observed during spring tides. Generally, the transport of larvae and early juvenile stages from spawning grounds to coastal nurseries involves both passive and active transport. Selective tidal current transport (e.g. plaice, Rijnsdorp *et al.*, 1985; sole, Grioche *et al.*, 2000; or brown shrimp, Cattrijsse *et al.*, 1997) can be considered as an active mechanism to select a prefered habitat. Indeed, other species such as dab, which form an important part of the demersal fish fauna in the subtidal of the studied area (Amara, 2003), did not show tidal migrations and did not move into the intertidal zone with the tide (Bolle *et al.*, 1994, this study). This suggests that the use of an intertidal area at ebb tide does not result from passive dispersion, but rather reflects an active choice.

Another important factor that can influence observed temporal variation in species abundance is predation. For a number of species, the vulnerability to predation is commonly high during and shortly after settlement. For example, predation by epibenthic crustaceans, such as *Crangon crangon* and *Carcinus maenas*, is an important factor regulating O-group plaice densities shortly after settling on nursery grounds (Edwards and Steele, 1968; Van der Veer, 1986; Pihl, 1990; Amara and Paul, 2003). In the present study, the high decreases in plaice densities just after the peak of settlement (early-May) may have been due to the coincidence with peaks in density of the two most potential predators: the brown shrimp and shore crab. Concerning the dominant species recorded in the studied area, the brown shrimp, the two main potential predators of young shrimps are gobies and seabass (Boddeke *et al.*, 1986; Hamerlynck and Cattrijsse, 1994; Cattrijsse *et al.*, 1997). In the tidal marshes of the Westerschelde (the Netherlands), a decrease in abundance of juvenile *C. crangon* has been attributed to the appearance of juveniles of these two fish species (Cattrijsse *et al.*, 1997). However in our study, predation by these two species is probably low during and following the peak of settlement, because seabass was not very abundant and gobies peak density occurred before shrimp settlement.

In conclusion, in spite of the harsh environmental conditions, the intertidal zone of the studied sandy beach seems to be used by a number of fish and epibenthic crustaceans species. The presence of many juveniles indicated the important role played by the open-sandy beach intertidal zone as a nursery ground. The brown shrimp, *Crangon crangon* and O-group plaice, *Pleuronectes platessa* are the two most abundant species of the intertidal ecosystem. The main structuring variables determining the occurrence and abundance of most of the species are water temperature, turbidity and dissolved oxygen. Biotic factors such as predation can affect species abundance particularly during the settlement period. Among biotic factors, it will be interesting to analyse the importance of food availability as a structuring factor determining the occurrence and abundance of species in the intertidal zone.

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